Overview of Salt Effect of Fertilizer on Nano-Silver Application in Soil

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Silver nanoparticles have been used in agricultural practice because of their biocide effect. However, limited information is available for the effect of silver nanoparticles on soil quality. Therefore, the main purpose of this study was to evaluate effect of silver nanoparticle application on soil especially when fertilizer is applied. To simulate potassium fertilizer, potassium chloride was mixed with silver nanoparticles in soil. Concentration of silver and chloride was measured and result showed that concentration of both compounds was decreased at the range of 3.4mg kg^{-1} and 78-84% respectively after treatment. In addition, analysis of microbial population after treatment showed that microbial population was increased when silver nanoparticles and KCl were mixed. Those results indicated that application of fertilizer has impact on biocide effect of silver nanoparticles in soil.

Key words: Silver nanoparticles, Fertilizer, Soil, Microbial population

Introduction

Nanotechnology has been considered as an emerging technology because of novel properties of nano-materials and potential application in industrial, agricultural and environmental fields (Liu, et al., 2003; Jacobson, et al., 2005; Rai, et al., 2009). In particular, silver nanoparticles have been widely used in agricultural practice due to its antimicrobial efficiency against bacteria, viruses and other micro-organisms (Rai, et al., 2009). However, still lack of information is available for fate of silver nanoparticles in soil after its application. Furthermore, application of fertilizer is a common practice in agricultural field and biocidal efficiency of silver nanoparticles can be altered due to chemical components in fertilizer.

Therefore, main objectives of this research were to evaluate salt effect of fertilizer on silver nanoparticles applied in soil and eventually assess soil quality for silver nanoparticle application in agricultural field.

Materials and Methods

Silver nanoparticles Silver nanoparticles were preapared in Pohang University of Science and Technology in Korea. In order to measure the particle size of silver nanoparticles, TEM(Transmission Electron Microscope) analysis was conducted. General particle size of silver nanoparticles was 10-30nm in solution. Physicochemical properties of silver nanoparticles were summarized in Table 1. Concentration of cation was measured with AAS(Atomic Absorption Spectrometer) and silver concentration was measured with ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectrophotometer, Perkin Elmer Optima 3100XL, USA).

Experiments Laboratory experiment was conducted to assess effect of fertilizer on silver nanoparticle application in soil. Soil samples were collected from Kyung-gi province in Korea. Collected soil samples were completely air dried and passed through a 2mm sieve for experiment. Physicochemical properties of soil such as pH, EC, organic matter, and CEC were measured. Five hundrad grams of soil were contained in the jar and varied concentration of silver nanoparticles (0, 25, 50, 100 mg L^{-1}) and potassium chloride(1.25 and 2.5mL of 0.1M KCl) was spiked to simulate ferilizer application (0.15 kg m^{-1}). Each prepared soilsamples were throughly mixed and air-dried again at room temperature. In order to measure silver concentration in soil, three grams of air dried soil samples were extracted with 28mL of aqua regia at 78℃ for 1hr and filtered with 0.45μm filter paper. Filtered samples were diluted with DI water and silver concentration was measured with ICP-AES. For chloride ion measurement, IC(Ion Chromatography) was used.

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Table 1. Chemical properties of silver nanoparticles.

pH(1:5)	EC	Ca	Mg	K	Na	Ag
	dS m^{-1}			mg L^{-1}		
4.26	11.02	N.D.	N.D.	0.10	0.90	998

N.D.: Not detected.

Microbial Population In order to vertify if biocide effect of silver nanoparticles was reduced after fertilizer application, microbial population was examined for each treatments. Fungi and bactria were injected into each treatment and number of bacteria and fungi was counted for 28 days.

Results and Discussion

Measured concentration of silver and chloride after silver nanoparticles were completely reacted with potassium chloride in soil was summarized in Table 2. Result showed that both silver and chloride concentration was decreased compared to control after treatments. Silver concentration of treated soil was ranged 1.37-10.32 mg kg^{-1} and about 3-4 mg kg^{-1} of silver was decreased compared to control regardless of spiked concentration. After treatment, chloride concentration in soil was also decreased compared to control. When no KCl was spiked in soil, chloride concentration was 4.15 mg kg^{-1} as background concentration. Since 18.64 and 37.28 mg kg^{-1} of chloride were spiked in soil, total chloride concentration in each soil was 22.79 and 41.43 mg kg^{-1} respectively and about 78-84% of chloride was reduced. This result indicated that silver nanoparticles were reacted with chloride and precipitation was occurred in soil.

Figure 1 shows the microbial population in each treatment. Result showed that higher microbial

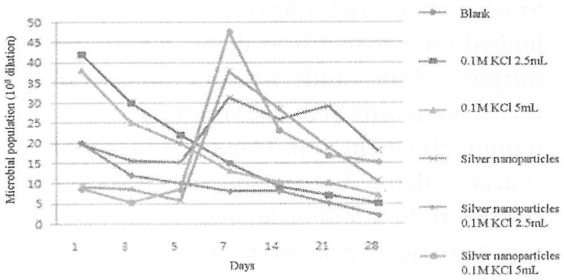

Fig. 1. Microbial population of each treatment.

population was observed in only KCl treatments compared to silver nanoparticles and KCl mixing treatments until 5 days. However, sharp increase of microbial population was observed in silver nanoparticles and KCl mixing treatment after 5 days and gradual decrease after 7 days. Meanwhile continuously decreased trend of microbial population was observed in only KCl treatment. This result indicated that biocide effect of silver nanoparticles was diminished when KCl was applied.

Conclusion

Biocide effect of silver nanoparticles was affected by KCl treatment in soil. When silver nanoparticles were mixed with KCl solution, concentration of silver and chloride was decreased at the range of 3-4mg kg^{-1} for silver nanoparticles and 78-84% for chloride respectively indicating that precipitation was occurred in soil. In

Table 2. Measured concentration of silver and chloride in soil. (mg kg^{-1})

Spiked concentration of KCl \ Spiked concentration of silver nanoparticles	25	50	100
		Silver concentation	
0	4.60	7.76	13.99
18.64	1.37	2.99	9.66
37.28	1.43	3.33	10.32
		Chloride concentration	
0	4.15	4.15	4.15
18.64	5.95	5.82	5.87
37.28	7.32	7.89	7.54

addition result of microbial population analysis showed that microbial population was increased in silver nanoparticles and KCl mixing treatment.

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토양 내 은나노 처리 시 비료에 의한 염류 효과

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은나노입자는 살균 효과 때문에 농업현장에서 사용되고 있다. 그러나 은나노입자가 토질에 미치는 영향에 대해서는 아직 많은 정보가 없다. 그러므로 비료가 처리 되었을 때 특히 토양에 은나노입자를 처리한 효과에 대한 검증이 반드시 필요하다. 가리계 비료를 모의 실험하기 위해서 토양에 염화가리를 은나노입자와 함께 처리하였다. 은과 염소의 농도는 처리 후 78 내지 84% 그리고 kg 당 3.4 mg 정도 감소하는 경향을 보였다. 그리고 은나노입자와 염화가리를 혼합하였을 때 미생물의 숫자가 증가하였다. 이러한 결과로부터 비료시용은 토양에서 은나노입자의 살생물 효과에 영향을 미친다.